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## Software and hardware for integrated ACS of casting quality

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## Software and hardware for integrated ACS of casting quality

**S V Knyazev, A A Usoltsev, D V Skopich, B M Sokolov and N V Oznobikhina**

Siberian State Industrial University, 42 Kirova Street, Novokuznetsk, 654007, Russia

E-mail: krookia@mail.ru

**Abstract.** The implementation of the “Automated system for the operational control of castings production (AS OCCP)” is the first stage and the basis of the integrated automated production control system. It performs three main tasks: control and accounting (the course of production, products, materials, etc.), improvement of the casting quality and the operational control of technological processes. The second stage is based on mathematical processing and analysis of data coming from AS OCCP, which allows the optimal ranges of parameters of technological processes – “Automated system for optimization and analysis of production progress (AS OAPP)” to be determined. AS OAPP consists of two subsystems: quality analysis (QAS) and technology Control (TCS). The first one solves the problems of data analysis and modeling, the second one – real-time calculation of optimal process parameters and forecasting. The tasks of the first and second stages compete for access to different hardware resources. The most critical parameter for the AS OCCP is the performance of the server disk arrays, for the AS OAPP is the processor performance. In both cases, the scaling of the system is effectively solved by parallelizing operations on different servers that make up the cluster, and on different processors (cores) on the same server.

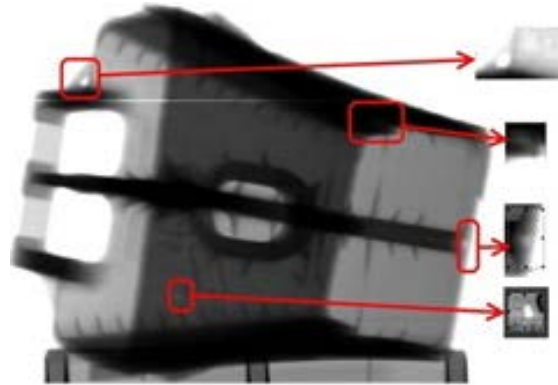
### 1. Introduction

To collect data on surface defects of castings, a formalized technique has been developed that significantly simplifies the process of technical control and allows the input of results into a computer to be organized in dialogue mode. At the same time, the problem is being solved that virtually eliminates the influence of the subjective perception of the operator-controller on the assessment of signs of casting-technological defects, both at the qualitative and quantitative levels [1, 3-9].

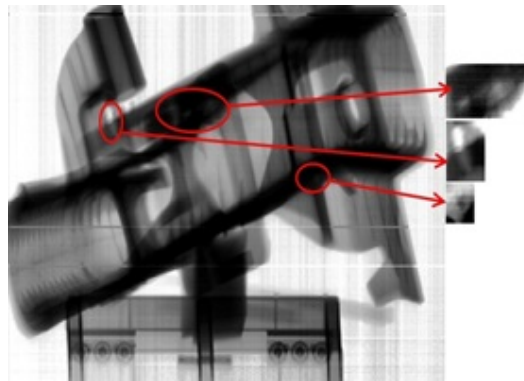
For non-destructive testing of internal casting-technological defects, the most informative in our opinion is the radiation scanning introscope – tomograph [2]. The mode and geometry of transmission were selected through preliminary experiments (figure 1, 2). The control of a complex casting with the help of scanning-type radiation introsopes is easier to automate than others. Scientists from Tomsk Polytechnic University have experience in developing similar equipment and providing it with software.

The implementation of the “Automated system for the operational control of casting production (AS OCCP)” in Rubtsovsk branch of Altayvagon JSC showed that this system allowed casting rejects and the cost of large car casting production to be reduced by an order. Basically, this was due to the full operational control of the production process and the observance of technological instructions by the personnel, as well as a decrease in the influence of the human factor [1,4,8,9].





**Figure 1.** The fragment of a bolster.



**Figure 2.** Fragment of the side frame.

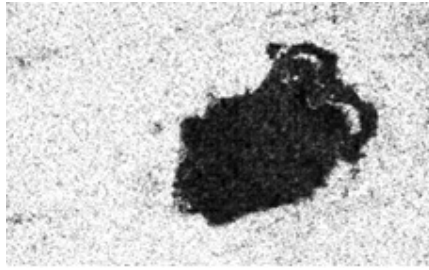
## 2. Results and discussions

AS OCCP is the first stage and the basis of an integrated automated production control system (APCS). The second stage in building an effective automated process control system solves the problems of stabilizing product quality when the external conditions change, for example, the quality of materials, and production optimization (change in the technology in order to reduce costs with constant or higher quality products). The second stage is based on mathematical processing and data analysis, coming from AS OCCP, allows the optimal ranges of parameters of technological processes – “Automated system for optimization and analysis of production progress (AS OAPP)” to be determined.

AS OAPP consists of two subsystems: quality analysis (QAS) and technology control (TCS). The first one solves the problems of data analysis and modeling, the second one – real-time calculation of optimal process parameters and forecasting. The tasks of the first and second stages compete for access to different hardware resources. The most critical parameter for the AS OCCP is the performance of the server disk arrays, for the AS OAPP is the processor performance. In both cases, the scaling of the system is effectively solved by parallelizing operations on different servers that make up the cluster, and on different processors (cores) on the same server.

The construction of cluster systems and parallel computations require appropriate software and hardware, as well as special approaches to the processing and storage of distributed data.

To process images of defects and obtain causal characteristics, the OpenCV software package can be used, which is a computer vision library with an open-source. The example of processing of such image is shown below (figures 3, 4, 5, 6). During processing, the Sobel operator, a Gaussian filter and binarization were used.



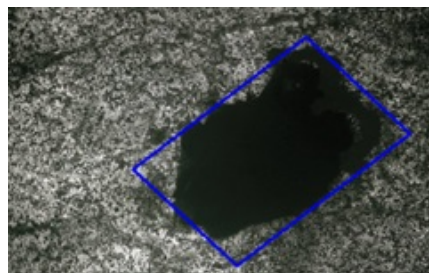
**Figure 3.** Processing by the Sobel operator.



**Figure 4.** Application of a Gaussian filter.



**Figure 5.** Binarization of the image.



**Figure 6.** Overlaying a contour on the defect.

According to the found contour, it is possible to calculate the necessary defect parameters. For example, the length of the faces and diagonals of a rectangular region, by which the shape and size of the gas shell can be determined. Further, having a decisive tree of cause-and-effect relationships the cause of the defect can be determined in a first approximation.

The presence of defects in the structure of castings can be influenced by many different factors that are identified on the basis of data statistical analysis. The AS OCCP keeps the history, the value of such factors and defectiveness for each product and group of products of the same smelting. One of the ways to determine the cause of a defect is the clusterization of AS OCCP data and reference of a defect to a particular cluster based on image recognition algorithms using, for example, Euclidean distances.

The task of clusterization is reduced to the determination by an expert method or using various mathematical algorithms of the defects belonging to a particular cluster (data block) according to the total values of dependent factors. Thus, data blocks are formed according to the criterion of the defect cause. Calculating the data block, to which the product defect belongs, can be a very time-consuming operation. It makes sense to place the data clusters on different servers in order to increase the efficiency of pattern recognition and parallelization of search operations.

Modern communication networks are based on asynchronous queries, so, it remains to choose between consistency and data availability, to a large extent it is a choice between relational and NoSQL DBMS. The popularity of NoSQL solutions is growing. The main advantage of such systems is the higher speed and flexibility of working with data due to bypassing the consistency mechanism and SQL syntax.

### 3. Conclusion

ApacheCassandra DBMS allows a strategy for distributing data among cluster nodes based on keys to be defined. The first distribution strategy is a random markup, distributes data based on a key hash value; the second is an ordinal markup, distributes data over ranges of the key bit values. Thus, it is possible to flexibly distribute various data blocks among the nodes of the system cluster ensuring their high availability. Development of AS OAPP based on a multi-node cluster with installed ApacheCassandra DBMS and usage of Nvidia video cards supporting CUDA technology on each node will be the cheapest and most effective solution. Video cards are selected based on the required number of graphics processors per node.

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